Butterfly diversity in relation to a human-impact gradient on an Indian university campus

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Abstract. The pattern of butterfly abundance and species richness are studied in wild (forest, scrub and grassland) and human-impacted (garden, plantation and grassland) areas in the 190-hectare campus of SGB Amravati University, Amravati, Maharastra, India. A total of 52 butterfly species belonging to Hesperiidae, Papilionidae, Pieridae, Lycaenidae and Nymphalidae families were recorded in five areas (biotopes). Species abundance rose from the beginning of the monsoon (June-July) and reached a peak in early winter (August-November). A decline in species abundance was observed from late winter (December-January) and continued up to the end of summer (May). The number of species within biotopes varied from 23 to 33; 17 species were noticeably absent in the disturbed and human-impacted sites (garden, plantation and grassland) and there was no occurrence of unique species in moderately disturbed areas comparable to those of less disturbed wild areas. On the basis of biotope occurrence, 67% of butterfly species were classified as disturbance-adaptable (occurring in all biotopes) and 33% as disturbance avoiders (restricted to wild areas such as forest, scrub and undisturbed areas elsewhere). Destruction of habitat is suggested to be the reason for the reduction of species richness and general abundance of butterflies in impacted areas of the university campus.

Introduction

The human impact on the global environment has triggered a mass extinction event of significance on a geological time scale as well as causing widespread changes in the global distribution of organisms (Chapin et al. 2000; Thomas et al. 2004). Among the insects, butterflies occupy a vital position in ecosystems and their occurrence and diversity are considered as good indicators of the health of any given terrestrial biotope (Kunte 2000; Aluri and Rao 2002; Thomas 2005). As herbivorous insects, the distribution of larval and nectar host plants has a distinct impact on the status of butterfly diversity (Culin 1997; Solman Raju et al. 2004).

Hence suitable measures for the conservation of larval and nectar host plants, and to deter destruction of natural biotopes, are needed to increase butterfly diversity in a given tropical ecosystem. Recently, Tiple et al. (2006) have identified various factors influencing nectar plant resource visits by butterflies on a university campus and advocated the value of university campuses in providing valuable resources for butterflies. The present study examines the human-impact gradient on the diversity of butterflies on the same university campus.

Methods

A field survey and investigation was carried out by the first author on a daily basis from July 2004 to June 2005 on the Sant Gadge Baba Amravati University campus situ-

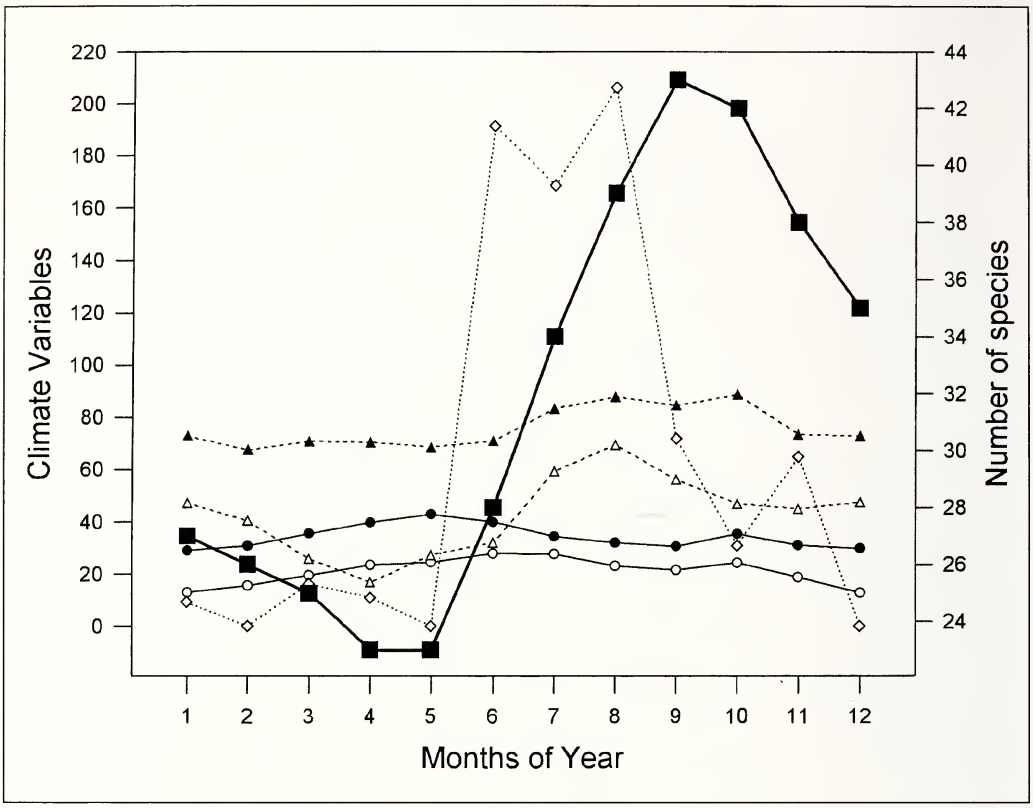

Fig. 1. Seasonal distribution in number of species on the Amravati University campus. Right scale: black squares, number of species. Left scale: climate variables: circles, temperatures (°C); closed circles, maximum mean temperatures (°C); open, minimum mean temperatures (°C); triangles, relative humidity (%); closed triangles, maximum relative humidity (%); open triangles, minimum relative humidity (%); diamonds, rainfall (cm).

ated about 4 km north east of Amravati city (20°50' N and 77°47' E) within an area of about 190 hectares (Tiple, unpublished M.Sc. thesis). Based on the human impact on campus biotopes (see Kunte 1997), the butterfly diversity was studied in five different areas (called sites). Observations were made during a fixed daily transect (500 m for each of the five areas) carried out between 7:00 h and 10:00 h; species were identified directly in the field or, in difficult cases, following capture or photography. Collection was restricted to those specimens that could not be identified directly. Butterflies were identified from Wynter-Blyth (1957), Gay et al. (1992), Kunte (2000), and Varshney (1983). Of the five study sites, the first is a hilly area to the east of the campus; it includes typical dry deciduous forest with teak trees as dominant species. The second site is a bank and the surrounding area of the university dam (reservoir), rich in scrub vegetation and a good source of water. The third site comprises widespread grassland occupying most of the area of the campus. A fourth site is dominated by the Botanical and Nursery Garden of the University campus; this site is rich in nectar host plants for butterflies. The final site is the plantation area around various departmental buildings of the university campus; this site is subject to a variety of human activities.

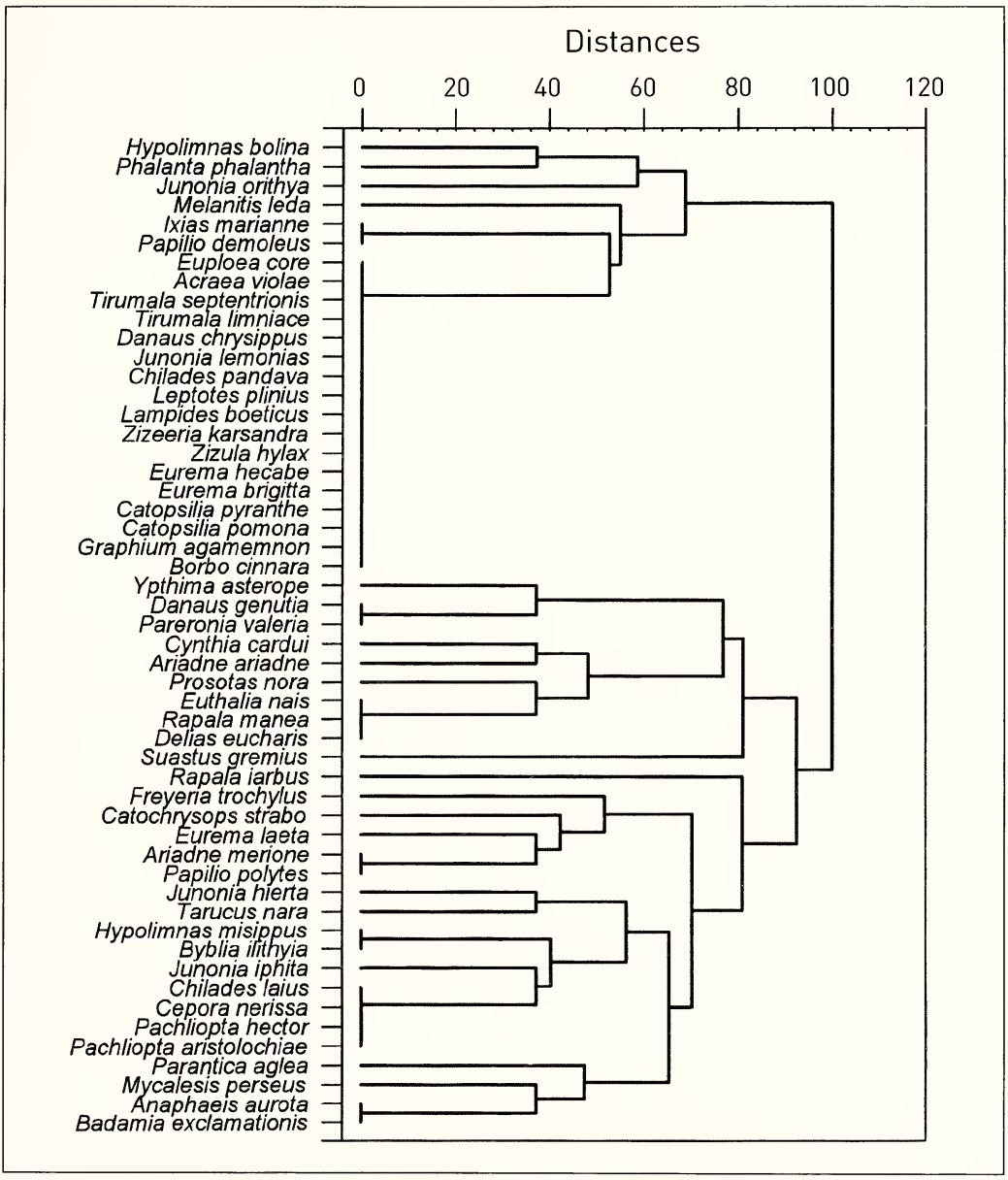

Fig. 2. Seasonal clustering of flight periods for butterflies on the SGB Amravati University campus, Amravati. Unweighted pair group average clustering based on Euclidean distances.

The present study focuses on contrasts in butterfly diversity between the biotopes of the five sites. Diversity and faunal associations are related to human impact and resource availability on the sites; correspondence analysis is applied to transect records in relation to the five sites and non metric scaling to Euclidean distances on scores for a range of resource and disturbance attributes, listed in Table 1, again for the five sites. Seasonal variation in flight periods is also examined for the campus using unweighted pair group average clustering based on Euclidean distances of the numbers of each

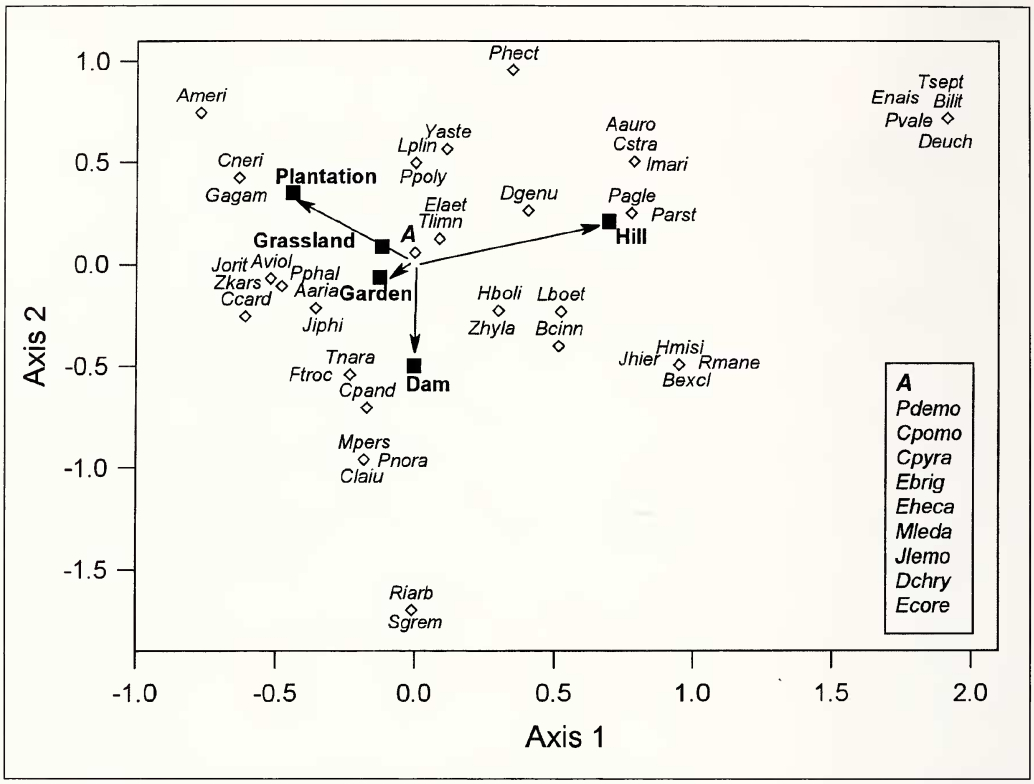

Fig. 3. Correspondence analysis plot of transect counts for butterflies recorded for the five sites on the SGB Amravati University campus, Amravati. '*A*' indicates species close to the origin of the plot and ubiquitous throughout the sites. Total inertia 0.35, $\chi^2_{(204)} = 4109$, $P < 0.0001$; axis 1, 37.3%; axis 2, 24.3%. Names of species include the first letter of the genus and the first three letters of the species (see Table 2).

species observed during different months. Nectar plants and nectaring events were reported earlier (Tiple et al. 2006). All analyses are conducted in STATISTICA (Statsoft 1999).

Results and Discussion

Diversity and Habitat. A total of 52 species of butterflies belonging to Hesperiidae, Papilionidae, Pieridae, Lycaenidae and Nymphalidae families were found on the university campus and their occurrence, status, and biotopes are listed in Table 2. Species richness according to the sites and a simple division of biotopes is noted in Table 3 together with the number of unique butterfly species for each site. Approximately two thirds of the butterfly species were recorded from the hilly area of the campus (site 1), six of which were unique and not recorded in other biotopes. Thirty two species were found in the scrub area (Dam, site 2), only two of which were unique species. About 30 species inhabited the extensive grassland (site 3) and 23 the plantation area (site 4), neither area having unique species. Thirty species were recorded, with two unique species, in the botanical and nursery garden (site 5). Out of 52 species, 49 were observed

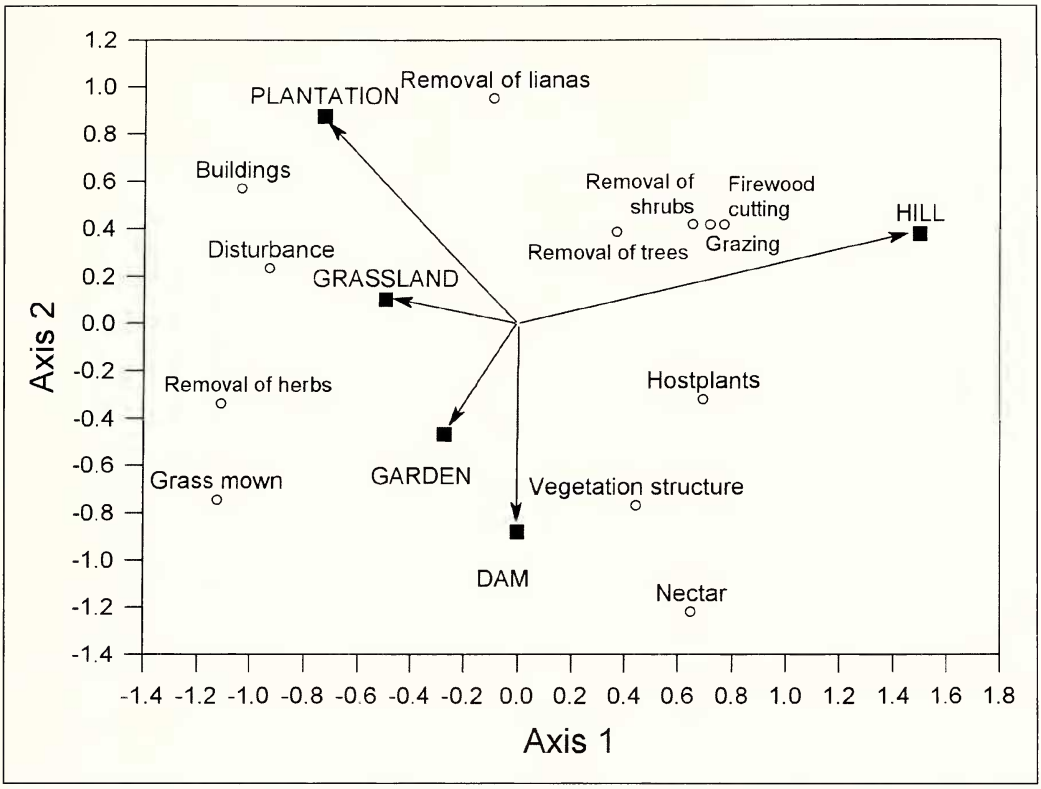

Fig. 4. Ordination of resource and disturbance attributes for the five sites on the SGB Amravati University campus, Amravati using non-metric multidimensional scaling of Euclidean distances based on the scores for attributes (Kruskal stress = 9.2%).

in wilder areas (forest, scrub, and grassland), eight of which were exclusive to them. The area in and around the various buildings of the campus, representing the most human-impacted zone, harbored a total of 35 species, none of which was unique. A few species of butterflies, viz. *Delias eucharis*, *Pareronia valeria*, *Byblia ilithyia*, *Euthalia nais* were unique to the forest biotopes while others, viz. *Papilio demoleus*, *Catopsilia pomona*, *Zizula hylax*, and *Danaus chrysippus* were observed generally in all the biotopes.

Seasonality. Seasonal patterns of species richness (flight periods) for the five sites, and the whole campus, are presented in Table 4 and Fig. 1. Seasonal clusters of species are recorded in Fig. 2; the pattern in the dendrogram corresponds closely with a non-metric scaling plot which has low Kruskal stress (8%). Most butterfly species were observed from the monsoon (hot/wet season) to early winter (cool/wet season) but thereafter declined in early summer (March) (Fig. 1). The cause of this decline might be non-availability of nectar and larval host plants, scarcity of water at the Dam site, and cutting of grasslands. The importance of resource types (consumer and utilities) is indicated in a number of studies in temperate contexts (Dennis et al. 2003), for example, the recorded

Tab. 1. Resource and disturbance attributes for sites on the SGB Amravati University campus, Amravati. [1]Relative abundance across species.

Attribute	Scores
Host plants[1]	1 rare, 2 frequent, 3 many
Nectar flowers[1]	1 rare, 2 frequent, 3 many
Vegetation structure	1 simple, 2 moderately varied, 3 complex
Disturbance from pedestrians	1 little, 2 moderate, 3 heavy
Buildings/tarmac/concrete	1 none, 2 few, 3 many
Removal of trees	1 little, 2 moderate, 3 severe
Removal of lianas	1 little, 2 moderate, 3 severe
Removal of shrubs	1 little, 2 moderate, 3 severe
Removal of herbs	1 little, 2 moderate, 3 severe
Grass mown	1 none, 2 moderate, 3 severe
Grazing	1 none, 2 moderate, 3 severe
Firewood	1 none, 2 moderate, 3 severe

shifts in nectar flower use with emergence period and broods (Porter et al. 1992). At the five sites, we observed that the build-up in the numbers of species and populations took place from the early monsoon and exhibited a first peak in the late monsoon followed at some sites by another peak in early winter (November) (Table 4). This might be related to resources required for somatic maintenance and reproduction which depend on nectar plants (Gilbert 1981).

Butterflies of all biotopes had very specific flight periods (Fig. 2), and following the short flight peak they were found to be rare or absent in other seasons (see Kunte 1997). The dendrogram (Fig. 2) breaks down into two large clusters, distinguishing species flying for much of the year (top) from those flying for shorter periods of the year (top and bottom); the latter breaks down further into two groups again left and right respectively into those appearing mainly in the winter months and those appearing during summer. Some species exhibited the unique character of occurring throughout the year with a short population peak during specific months. Occurrence for only a few months was noted in *Rapala iarbus*, *Euthalia nais*, *Junonia hierta* and *Mycalesis perseus* within forest or scrub. Some species, viz. *Delias eucharis*, *Pareronia valeria* and *Hypolimnas misippus* in the forest, had single short flight periods whereas *Rapala manea* exhibited two short flight period peaks at the Dam site. *Danaus chrysippus*, *Eurema brigitta* and *Euploea core* in the grassland were regularly observed throughout the year.

Human activity impacts. Recent reports reveal that about 100 out of 1500 butterfly species occurring in India are on the verge of extinction (Solman Raju & Rao 2002). A number of colonies of butterflies have been exterminated by human activities, resulting in changes to habitats beyond the tolerance limit of the species.

Multivariate analysis (correspondence analysis) of transect counts in the present study reveal that although some butterflies are ubiquitous (Fig. 3; e.g. '*A*' characterizes nine

Tab. 2. Occurrence, status and biotopes of butterfly species and a summary of the human impact gradient on them at SGB Amravati University campus, Amravati. [1]Status: VC, Very common (> 100 sightings); C, Common (50–100 sightings); NR, Not rare (15–50 sightings); R, Rare (2–15 sightings); VR, Very rare (< 2 sightings); [2]Biotope: F, Forest; S, Scrub; G, Grassland; P, Plantation; B, Botanical and nursery garden. [3]Impact classification: AD, Adapter; AV, Avoider.

Butterfly species	**Occurrence (months)**	**Status[1]**	**Biotope[2]**	**Impact gradient[3]**
Hesperiidae				
Badamia exclamationis Fabricius	8–10	R	F	AV
Suastus gremius Fabricius	1–2	VR	S	AV
Borbo cinnara Wallace	1–12	VC	FSB	AD
Papilionidae				
Papilio polytes Linnaeus	6–12	NR	FGPB	AD
Papilio demoleus Linnaeus	3–12	VC	FSGPB	AD
Pachliopta aristolochiae Fabricius	7–9	R	FB	AD
Pachliopta hector Linnaeus	7–9	R	FP	AD
Graphium agamemnon Fabricius	1–12	C	GPB	AD
Pieridae				
Catopsilia pomona Fabricius	1–12	C	FSGPB	AD
Catopsilia pyranthe Linnaeus	1–12	VC	FSGPB	AD
Eurema brigitta Wallace	1–12	VC	FSGPB	AD
Eurema hecabe Linnaeus	1–12	VC	FSGPB	AD
Eurema laeta Moore	7–12	C	FSGP	AD
Delias eucharis Drury	10–12	VR	F	AV
Anaphaeis aurota Fabricius	8–11	R	FG	AV
Ixias marianne Cramer	3–12	C	FG	AD
Cepora nerissa Fabricius	7–9	R	GPB	AD
Pareronia valeria Fabricius	9–4	VR	F	AV
Lycaenidae				
Zizula hylax Fabricius	1–12	C	FSGB	AD
Zizeeria karsandra Moore	1–12	C	SGPB	AD
Freyeria trochylus Kollar	8–-12	C	SGB	AD
Lampides boeticus Linnaeus	1–12	C	FSG	AD
Chilades laius Stoll	7–9	R	SB	AV
Prosotas nora Moore	10–11	VR	SB	AV
Leptotes plinius Fabricius	1–12	C	FGPB	AD
Tarucus nara Moore	5–10	VC	SGB	AD
Catochrysops strabo Fabricius	6–11	C	FG	AD
Chilades pandava Horsfield	1–12	C	SG	AV
Rapala manea Moore	10–12	VR	FS	AV
Rapala iarbus Kollar	5–7	VR	S	AV

Tab. 2. Continuation.

Nymphalidae				
Melanitis leda Drury	8–5	VC	FSGPB	AD
Mycalesis perseus Fabricius	9–10	R	SB	AV
Ypthima asterope Moore	10–4	C	FPB	AD
Junonia hierta Fabricius	5–9	VC	FS	AV
Junonia lemonias Linnaeus	1–12	VC	FSGPB	AD
Junonia orithya Linnaeus	8–2	VC	SGPB	AD
Junonia iphita Cramer	8–9	VR	B	AD
Danaus chrysippus Linnaeus	1–12	VC	FSGPB	AD
Danaus genutia Linnaeus	9–-4	C	FGB	AD
Tirumala limniace Cramer	1–12	C	FSGP	AD
Tirumala septentrionis Cramer	1–12	R	F	AV
Parantica aglea Cramer	9–11	R	SB	AV
Phalanta phalantha Drury	6–3	VC	SGPB	AD
Euthalia nais Forster	10–12	R	F	AV
Byblia ilithyia Drury	6–9	R	F	AV
Acraea violae Fabricius	1–12	C	SGP	AD
Ariadne merione Cramer	6–12	C	GP	AD
Ariadne ariadne Johanssen	10–1	R	B	AD
Cynthia cardui Linnaeus	10–2	C	SP	AD
Euploea core Cramer	1–12	VC	FSGPB	AD
Hypolimnas misippus Linnaeus	6–9	R	FS	AV
Hypolimnas bolina Linnaeus	7–3	C	FSGB	AD

species), many tend to be found more in one biotope or another (e.g. Hill biotope: *Tirumala septentrionis* and *Euthalia nais*; Dam biotope: *Rapala iarbus* and *Suastus gremius*; Plantation biotope: *Cepora nerissa* and *Ariadne merione*). A non-metric scaling plot of biotope attributes reveals that biotopes contrast in vegetation structures and resources. The contrasts in diversity might relate to the occurrence of nectar plants and larval host plants used by a majority of butterfly species. The Dam and Hill have complex vegetation structures and substantial resources of host plants and nectar, whereas the Plantation and Grassland sites score lower for resource and vegetation complexity; the Garden site is intermediate between these groups. Similarly, the Plantation and Grassland experience the most serious disturbance (building, human activity, grass mowing); nevertheless, the Dam and Hill areas experience different kinds of disturbance, mostly removal of material for fires and grazing, which carry consequences for butterfly populations (Fig. 4).

In the present study, the areas under greatest human impact were the plantation site around buildings on the university campus, grassland, and hilly forest. The removal/destruction by human activity of naturally growing nectar and larval host plants har-

Tab. 3. Species richness in the five sites (biotopes) and for 'wild areas' and 'impacted areas' of SGB Amravati University campus, Amravati. Wild and human-impacted areas are distinguished by the occurrence or absence of forest, scrub, and undisturbed grassland zones in the five biotopes.

Biotopes	**No. of total species**	**No. of unique species**
Hill site (forest) (F)	33	6
Dam site (scrub) (S)	32	2
Grassland site (grass) (G)	30	0
Plantation site (plantation) (P)	23	0
Garden site (botanical and nursery garden) (B)	30	2
Wild area (in F,S,G,B)	49	8
Impacted area (in P,G,B)	35	0

Tab. 4. Seasonal variation in species richness at the five sites of SGB Amravati University campus, Amravati.

Sites/Months	**June – July**	**Aug – Sep**	**Oct – Nov**	**Dec – Jan**	**Feb – Mar**	**Apr – May**
Hill site	9	10	8	7	4	3
Dam site	3	13	10	8	4	1
Grassland site	12	18	13	8	5	2
Plantation site	5	9	11	5	3	1
Garden site	7	12	14	9	5	4

boring eggs, larvae, and pupae of butterflies has a great impact on richness, abundance and diversity of butterfly species. It is important to note that the diversity of butterflies was also adversely affected by grass cutting, exposing butterflies to their natural predators, and unauthorized grazing and cutting of plants for firewood at the Hill site on the campus. On the basis of biotope occurrence, 67% of butterfly species were classified as disturbance-adaptable (occurring in all biotopes) and 33% as disturbance avoiders (restricted to wild areas such as forest, scrub, and undisturbed areas elsewhere) (Table 2). Butterflies like the *Euploea core*, *Eurema brigitta*, *Catopsilia pomona*, *Danaus chrysippus*, and *Tirumala limniace* have the ability to survive in adverse biotopes and are ubiquitous. Destruction, degradation or fragmentation of biotopes are the most worrying causes of butterfly species extinction. Hence, control of the exploitation of natural biotopes for butterflies, including shrub, herb, and trees, dried and green grasses (e.g. grazing) would definitely help to maintain and increase the diversity of butterflies in areas protected like the campus of SGB Amravati University.

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